Defense Threat Reduction Agency
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DTRA-TR-14-18

TECHNICAL REPORT

1962 Satellite High Altitude Radiation Belt Database

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March 2014

Prepared by:
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14. ABSTRACT
The AFRL data base for the Russian II and III events has been updated based on comments provided in AFRL-VS-PS-TR-2006-1093 by Dr. Bernard Roth. The data base has been reconverted from integral to differential form based on the original conversion program. The recorded count rates documented in the database are reproduced exactly. The differential data have been adjusted for the improved geometrical factors reported in Radiation Trapped in the Earth's Magnetic Field [We66] and a slight correction to the original loss cone calculation described below. The error estimates provided by Pfitzer in [Pf82] have been retained. A second set of data files have been produced by converting the two data sets back to integral form with a slightly simpler algorithm.

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CONVERSION TABLE

Conversion Factors for U.S. Customary to metric (SI) units of measurement.

MULTIPLY → BY → TO GET
TO GET ← BY ← DIVIDE

angstrom	1.000 000 x E -10	meters (m)
atmosphere (normal)	1.013 25 x E +2	kilo pascal (kPa)
bar	1.000 000 x E +2	kilo pascal (kPa)
barn	1.000 000 x E -28	meter^2 (m^2)
British thermal unit (thermochemical)	1.054 350 x E +3	joule (J)
calorie (thermochemical)	4.184 000	joule (J)
cal (thermochemical/cm^2)	4.184 000 x E -2	mega joule/m^2 (MJ/m^2)
curie	3.700 000 x E +1	*giga bacquerel (GBq)
degree (angle)	1.745 329 x E -2	radian (rad)
degree Fahrenheit	$t_k = (t^{\circ}f + 459.67)/1.8$	degree kelvin (K)
electron volt	1.602 19 x E -19	joule (J)
erg	1.000 000 x E -7	joule (J)
erg/second	1.000 000 x E -7	watt (W)
foot	3.048 000 x E -1	meter (m)
foot-pound-force	1.355 818	joule (J)
gallon (U.S. liquid)	3.785 412 x E -3	meter^3 (m^3)
inch	2.540 000 x E -2	meter (m)
jerk	1.000 000 x E +9	joule (J)
joule/kilogram (J/kg) radiation dose absorbed	1.000 000	Gray (Gy)
kilotons	4.183	terajoules
kip (1000 lbf)	4.448 222 x E +3	newton (N)
kip/inch^2 (ksi)	6.894 757 x E +3	kilo pascal (kPa)
ktap	1.000 000 x E +2	newton-second/m^2 ($N\text{-}s/m^2$)
micron	1.000 000 x E -6	meter (m)
mil	2.540 000 x E -5	meter (m)
mile (international)	1.609 344 x E +3	meter (m)
ounce	2.834 952 x E -2	kilogram (kg)
pound-force (lbs avoirdupois)	4.448 222	newton (N)
pound-force inch	1.129 848 x E -1	newton-meter (N-m)
pound-force/inch	1.751 268 x E +2	newton/meter (N/m)
pound-force/foot^2	4.788 026 x E -2	kilo pascal (kPa)
pound-force/inch^2 (psi)	6.894 757	kilo pascal (kPa)
pound-mass (lbm avoirdupois)	4.535 924 x E -1	kilogram (kg)
pound-mass-foot^2 (moment of inertia)	4.214 011 x E -2	kilogram-meter^2 ($kg\text{-}m^2$)
pound-mass/foot^3	1.601 846 x E +1	kilogram-meter^3 (kg/m^3)
rad (radiation dose absorbed)	1.000 000 x E -2	**Gray (Gy)
roentgen	2.579 760 x E -4	coulomb/kilogram (C/kg)
shake	1.000 000 x E -8	second (s)
slug	1.459 390 x E +1	kilogram (kg)
torr (mm Hg, 0^0 C)	1.333 22 x E -1	kilo pascal (kPa)

*The bacquerel (Bq) is the SI unit of radioactivity; 1 Bq = 1 event/s.
**The Gray (GY) is the SI unit of absorbed radiation.

September 2009 Update Of AFRL STARAD Database

By Dr Pat McDaniel

University of New Mexico

September 2009

Summary: The AFRL data base for the Russian II and III events has been updated based on comments provided in AFRL-VS-PS-TR-2006-1093 by Dr. Bernard Roth. The data base has been reconverted from integral to differential form based on the original conversion program. The recorded count rates documented in the database are reproduced exactly. The differential data have been adjusted for the improved geometrical factors reported in Radiation Trapped in the Earth's Magnetic Field [We66] and a slight correction to the original loss cone calculation described below. The error estimates provided by Pfitzer in [Pf82] have been retained. A second set of data files have been produced by converting the two data sets back to integral form with a slightly simpler algorithm.

Dr. Roth's Critique: In AFRL-VS-PS-TR-2006-1093 Dr. Bernard Roth presents an extensive critique of the AFRL STARAD database. Essentially all of his points are valid criticisms, and many reflect criticisms based on what one would like to have in a data base that doesn't exist. The uncertainties in the STARAD database are large for many of the reasons that Dr. Roth points out. But some of the problems can be fixed. This has been attempted. Some of the problems are unfixable because the data is simply not there, usually because the importance of some variable was not realized at the time the data was taken, or the instrumentation was inadequate for the task of measuring it. The most glaring failure of the database appears to be the inability of the AFRL database to predict the omni-directional data reported by H. West in his article in Radiation Trapped in the Earth's Magnetic Field [Mc66], Figures 18 and 19. This effort has addressed this specific issue.

Reprocessing the Data: The STARAD data files currently in the AFRL database are reported in integral form to be consistent with the other data files stored there. However the data was collected in differential form, both in energy, and in angle. Dr. Karl Pfitzer converted the original differential direction data to omni-directional electron fluxes, but was unable to convert the energy differential data to integral form [Pf82]. The energy differential data was converted to integral form by Mr. John Burgio of AFWL/NTY. For comparison with published data it is often useful to have the original differential data. An effort was made to recover the original differential data.

Dr. Roth gives an excellent description of how one can recover the differential data from the integral data in Appendix C of AFRL-VS-PS-TR-2006-1093. This analysis follows exactly an inversion of the computer program used by Mr. Burgio to produce the integral data in the first place. Mr. Burgio used two computer programs (very similar) to convert the Russian II data and the Russian III data. Both programs were available in saved archives. A program was written to implement a reversion of the algorithms that Mr. Burgio used to recover the differential data. This reversion follows very closely the procedure that Dr. Roth had outlined.

Upon reverting the data back to differential form, it was possible to check the validity of the reversion by comparing a calculated count rate with the recorded count rate in the database. The differential electron fluxes in the database are derived from the measured count rates based on the following relationships.

$$FLX_{ch}+BKG_{ch}=(COUNTS_{ch}-C_{ch}*C_I)*ST/G_{ch}$$

$$BKG_{ch}=(BKGCOUNTS_{ch}-C_{ch}*C_I)*ST/G_{ch}$$

Where,

FLX_{ch} = Electron flux reported in electrons/cm^2/sec/kev for energy channel ch,

BKG_{ch} = Electron flux measured prior to event under consideration,

$COUNTS_{ch}$ = Actual recorded detector energy channel counts/sec,

C_I = Interference counts recorded in the shielded detector due to electron bremsstrahlung and high energy protons that is assumed to affect the three highest energy channels,

C_{ch} = Fraction of counts from the shielded detector that represents an interference count in the three highest energy channels,

ST = A simple solid angle factor that converts a directional measurement to an omni-directional measurement by assuming that the flux out side of the loss cone is constant,

G_{ch} = A geometric factor that converts the counts observed in a detector channel to the equivalent electron flux,

$BKGCOUNTS_{ch}$ = The counts observed in the detector prior to the event under consideration.

It is important to recognize that four types of corrections were made to the measured data in transitioning from a single pitch angle measurement of electron flux to the omni-directional electron flux. First the measured counts were corrected for an interference background due to high energy protons and electron bremsstrahlung that penetrated the shielding. This correction was based on a background interference channel in the detector array that was well shielded from direct electron fluxes. (For the purposes of this note, this "background" will be referred to as an "interference" correction rather than background, so as to distinguish it from the background fluxes that were present before a burst.) Then the directional measurement was converted to an omni-directional measurement by assuming the flux was not a function of pitch angle outside of the loss cone. This is not a good assumption and produces the greatest uncertainty in the reported data. The third correction converts the recorded counts to electron fluxes. This is accomplished with a geometric factor that was developed from calibration experiments. Finally a pre-shot background was subtracted from each measurement. For the highest energy channel this background in many cases is very close to the measured flux and the uncertainty estimates for the reported data are enormous. However in some cases the signal to background ratio for the fluxes in this highest energy channel can be as large as 5 to 1, so in these cases the signal might be useful.

After the current data were reverted from integral to differential form, an attempt was made to invert the above equation and recover the measured counts. When this was done on the Russian II STARAD data base the calculated counts matched the measured counts for the first two energy channels very accurately, usually within less than a per cent. However the calculated counts in the upper three energy channels were off on the order of 20% in most cases. This presented a dilemma. It appeared that the source of the discrepancy was the coefficient used to correct the measured counts for the recorded counts in the interference channel. The coefficients for this correction reported in the AFRL database and recorded in [Pf82] are given in Table No. 1 in the reported column.

Table No.1:Interference Correction Coefficients

Channel	Energy	Reported	Corrected
1	0.325 MeV	0.0	0.0
2	0.955 MeV	0.0	0.0
3	1.630MeV	1.0	0.4
4	2.400 MeV	0.75	0.75
5	3.250 MeV	0.4	1.0

It seemed odd that a larger correction for interference should be required for the 1.63 MeV channel than for the 3.25 MeV channel since no correction was required for the 0.955 MeV channel. So the reversion program was run again with the corrected set of interference coefficients listed above. With the new set of coefficients, monotonically increasing with increasing channel energy, the calculated fluxes for all five energy channels matched the recorded counts to within a percent for most data points. So it appears that the interference coefficients actually used in the data reduction by Pfitzer were actually the corrected set. Nowhere in any of West's reports are these correction coefficients mentioned. They must have come from the computer program that was provided to Pfitzer by Dr. Kuck [Pf82]. It is impossible to say if they are the correct ones, but they definitely are the ones used by Pfitzer in his computer program.

By resolving this issue, it was also possible to reconstruct the interference counts used to perform the correction. These interference counts are now recorded in the STARAD data files for future analysis as the C6 count data.

Having recovered the original count rate data, an investigation was made of the best geometric coefficients to use to reconvert it to differential electron fluxes. West has published 3 sets of geometric coefficients listed below in Table No. 2. His calibration improved with time and the last set [We66] were exactly 1.5 times the previous set [We64]. For some reason Pfitzer chose the middle set of coefficients in setting up the original data files. At this time the later set

[We66] appear more accurate and they were used to transform the recorded counts to differential electron fluxes. This is essentially one of the recommendations that Roth made in his report. [Ro06]. West noted in [We66] that he had rechecked his calibration after his measurements appeared low compared with other satellite measurements of the trapped electron fluxes from the Russian II test.

Table No. 2: West's Geometric Coefficients

Channel Energy	[We63]	[We64]	[We66]
0.325	0.251	0.221	0.147
0.955	0.364	0.452	0.301
1.630	0.364	0.415	0.276
2.400	0.503	0.540	0.360
3.250	0.540	0.565	0.377

Finally the fluxes, differential in angle, had to be converted to omni-directional fluxes to be compatible with other files in the database and to be useful for comparison with current generation prediction codes. Since Pfitzer had rejected all data points within 10 degrees of the predicted loss cones, the conversion to omni-directional fluxes avoided very low differential flux measurements being used to represent the average flux out of the loss cone. However, he never quite got the conversion factor correct in any of the documentation [Pf82],[Pf88]. The correct formula for the solid angle outside of the loss cone is

$$\Omega = 4\pi\sqrt{1.0 - \frac{B}{B_E\sqrt{4-3/L}}}$$

Where

Ω = the solid angle outside of the loss cone,

B = the magnetic field strength at the data point,

B_E = the earth's magnetic dipole strength, 0.311 Gauss

L = McIlwain's L parameter at the data point.

This formula actually applies to the loss cone for an ideal dipole located at the center of the Earth. When it was used to try to predict the actual count rates from the reverted differential

fluxes, it led a very accurate prediction of the count rates, so it appears that the analysis was better than the documentation.

If one considers an off-center dipole tilted in the direction of northern Canada, this formula should be corrected by the ratio of the top of the atmosphere in the South Atlantic Anomaly to the surface of the earth considering the off center shift of the dipole away from the South Atlantic Anomaly. When this effect is taken into account, the B in the above equation is multiplied by (R_m/R_E) to the third power and the L in denominator is multiplied by an (R_m/R_E) to the first power. R_m is the distance from the center of the off center dipole to the surface of the Earth plus the 100 km height of the atmosphere in the South Atlantic Anomaly. $R_m = R_E + 535$ km. R_E is the radius of the Earth. The correction is usually less than 5%, but it was included in calculating the new differential fluxes.

Integral Data Files: In order to be compatible with the other data files in the AFRL Database, the STARAD data files were once again converted to integral files. Both differential and integral files were prepared. The integral data files are identified as R2_ISTRD.DAT and R3_ISTRD.DAT. The differential data files are identified as R2_DSTRD.DAT and R3_DSTRD.DAT. In the integral files prepared by Mr. Burgio, the flux above the measured 3.25 MeV channel was assumed to fall off exponentially with an e-folding constant of 0.9 MeV up to 8.0 MeV. The endpoint of 8.0 MeV is very understandable as it is probably the largest energy that a fission product beta particle can attain. If more energy is available for a fission product decay, a heavy particle, usually a neutron, is the normal emission. Though the 0.9 MeV e-folding constant is plausible, no real justification has been found. So an attempt was made find a better e-folding constant.

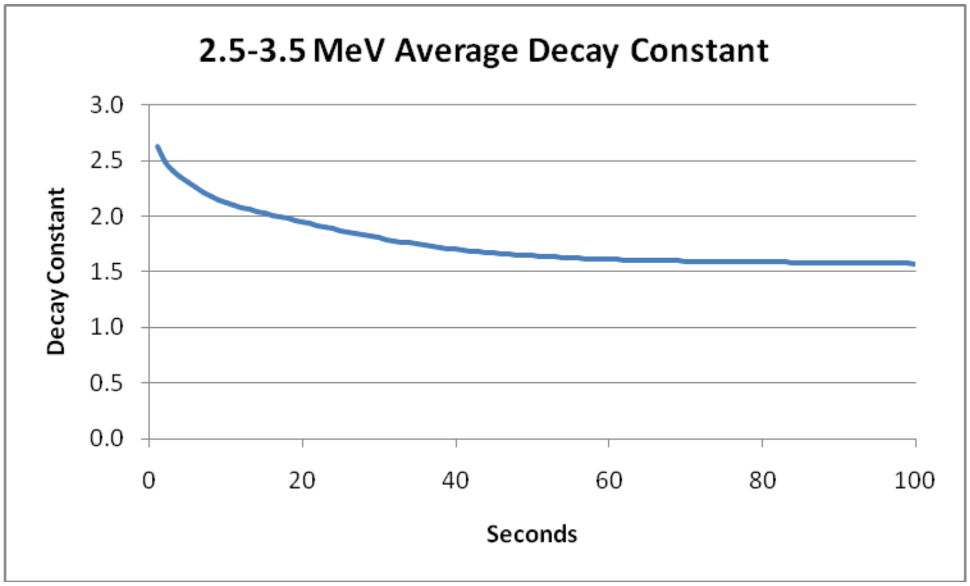
In the Carter-Reines spectrum [Ca59] at 3.25 MeV the instantaneous e-folding constant is 1.327 MeV. So this should be a good approximation. However, it was thought that the actual data might be a better choice to estimate this constant. So an average of the exponential decay between the 2.4 MeV channel and the 3.25 MeV channel in the differential data was calculated. This average gave a decay constant of 1.317 MeV for the Russian II data and 2.549 MeV for the Russian III data. This made the choice for the Russian II integral files fairly easy. The average decay across the two highest energy channels seemed like a reasonable choice. However, It might be better in the future to perform a fit to this decay constant as a function of L, B, and time since burst, but that was a little too much work for this effort.

The value of 2.549 MeV seemed a little hard for the Russian III data. So the fission product impulse functions of LaBauve et al. [La82] were checked. LaBauve et al. fitted a series of CINDER runs with exponential decay functions by energy group. They used a group structure of 0.0-1.0, 1.0-2.0, 2.0-3.0, 3.0-4.0, 4.0-5.0, 5.0-6.0, and 6.0-7.5 MeV. (Part of the funding for LaBauve's work was provided by AFWL/NTYS to address the issue of time dependent beta decay spectra.) So an average decay constant for the exponential decay between the 2.0-3.0 MeV and 3.0-4.0 MeV energy groups for U-235 was calculated as a function of time for the first 100 seconds after fission. The results of these calculations are presented in Figure No. 1. Note that for early times, the decay constant is greater than 2.5 MeV and it settles out at a little above 1.5 MeV. This seemed to say that the decay constant for the Russian III data could be as large as 2.549 MeV and so this e-folding constant was used for the energy spectrum above the

differential 3.25 MeV measurement. Once again, a more detailed fit might produce better results, but the effort to do that was beyond the scope of this work.

Once the issue of the spectrum above the highest energy group was resolved, the solution for all lower energy groups was rather straightforward. Either of two forms for the energy spectrum between differential measurements could easily match the data. Mr. Burgio chose a power law

Figure No. 1: Average Decay Constant for the U-235 Fission Product Impulse Functions of LaBauve et al. based on CINDER calculations. [La82]



which required an iterative procedure to invert. It is much more straightforward to use an exponential decay between differential measurements, and is easier to check, so that is the process that was used for this set of integral data files.

The equations used to calculate the integral fluxes from the differential fluxes are,

$$\Phi_{3.25} = \int_{3.25}^{8.0} \phi_{3.25} \exp(-(E-3.25)/E_{decay,3.25})dE$$

Where

$\Phi_{3.25}$ = the integral flux above 3.25 MeV

$\phi_{3.25}$ = the differential flux at 3.25 MeV

$E_{decay,\,3,25}$ = e-folding energy above 3.25 MeV

= 1.317 MeV for Russian II

$$= 2.549 \text{ MeV for Russian III}$$

$$E_{decay,I->I+1} = \frac{E_{I+1} - E_I}{\ln\left(\frac{\phi_I}{\phi_{I+1}}\right)}$$

And

$$\Delta\Phi_{I,I+1} = \int_{E_I}^{E_{I+1}} \phi_I \exp(-(E - E_I)/E_{decay,I->I+1})dE$$

Where

$E_{decay,I->I+1}$ = the exponential e-folding constant for the interval from E_I to E_{I+1},

ϕ_I = the differential electron flux at energy E_I,

$\Delta\Phi_{I,I+1}$= the integral flux increment for the interval E_I to E_{I+1}.

The background integral fluxes were estimated with the same equations. The fractional integral uncertainties were estimated as the geometric mean of the fractional uncertainties of the differential fluxes on either end of an energy interval. The fractional integral uncertainty for the highest energy interval was set equal to the fractional uncertainty for the highest energy differential flux.

Comparison of the Differential Data with that Reported in RTEMF [We66]: It seems the issue that started this investigation in the first place was that the data in West's article in [We66] did not match the data in the AFRL database files. So it is worthwhile to compare the two at this point. In particular the data from Figure 19 of [We66] was digitized. It is compared below to the nearest current point in the STARAD differential data files in Table No. 3.

Table No. 3: Comparison of STARAD Differential Data File with [We66]

Channel Energy (MeV)	Point 1	Record 376	Ratio
0.325	1.50E+5	1.577E+5	1.05
0.955	7.00E+4	9.564E+4	1.37
1.630	3.80E+4	6.881E+4	1.81
2.400	1.25E+4	7.557E+3	0.605
3.250	4.20E+3	2.955E+3	0.704
L=	2.008	2.005	
B=	0.0628	0.063	
λ=	19.0 deg	19.3 deg	

T=	~7.5 hr	6.987 hr	

Channel Energy (MeV)	Point 2	Record 400	Ratio
0.325	3.80E+5	3.587E+5	0.944
0.955	1.30E+5	1.954E+5	1.50
1.630	5.30E+4	6.675E+4	1.26
2.400	1.10E+4	5.468E+3	0.497
3.250	5.20E+3	9.270E+2	0.178
L=	2.045	2.046	
B=	0.1335	0.131	
λ=	31.8 deg	31.9 deg	
T=	~7.5 hr	7.498 hr	

Channel Energy	Point 3	Record 325	Ratio
0.325	1.50E+5	3.317E+5	2.21
0.955	1.05E+5	1.260E+5	1.20
1.630	4.30E+4	4.354E+4	1.01
2.400	1.40E+4	7.410E+3	0.529
3.250	5.20E+3	3.539E+2	0.068
L=	2.202	2.202	
B=	0.0658	0.066	
λ=	25.1 deg	25.2 deg	
T=	~7.5 hr	6.917 hr	

Channel Energy	Point 4	Record 423	Ratio
0.325	2.05E+5	2.751E+5	1.34
0.955	4.80E+4	7.073E+4	1.47
1.630	1.20E+4	1.937E+4	1.61
2.400	6.90E+3	5.505E+3	0.798
3.250	2.10E+3	1.681E+1	0.008
L=	2.216	2.225	
B=	0.1498	0.148	
λ=	36.1 deg	36.4 deg	
T=	~7.5 hr	7.534 hr	

Channel Energy	Point 5	Record 298	Ratio
0.325	1.05E+5	1.822E+5	1.74
0.955	4.70E+4	4.805E+4	1.02

1.630	2.00E+4	1.575E+4	0.788
2.400	8.50E+3	3.612E+3	0.425
3.250	2.95E+3	1.114E+3	0.378
L=	2.335	2.324	
B=	0.0679	0.068	
λ=	28.4 deg	28.1 deg	
T=	~7.5 hr	6.882 hr	

Channel Energy	Point 6	Record 426	Ratio
0.325	1.05E+5	1.425E+5	1.36
0.955	1.40E+4	2.339E+4	1.67
1.630	7.90E+3	9.495E+3	1.20
2.400	3.40E+3	2.382E+3	0.701
3.250	1.30E+3	6.810E+2	0.524
L=	2.334	2.347	
B=	0.1596	0.158	
λ=	38.7 deg	38.8 deg	
T=	~7.5 hr	7.553 hr	

Channel Energy	Point 7	Record 292	Ratio
0.325	1.05E+05	1.608E+5	1.53
0.955	3.30E+4	3.064E+4	0.928
1.630	1.70E+4	1.394E+4	0.820
2.400	8.00E+3	2.747E+3	0.343
3.250	3.00E+3	1.058E+3	0.353
L=	2.412	2.427	
B=	0.0690	0.069	
λ=	29.8 deg	30.2 deg	
T=	~7.5 hr	6.856 hr	

The 3.25 MeV channel underestimates West's data by 31% on average. Perhaps it is best to look at the best and worst two data points for comparison. The best comparison is Point 1 where the Data Base value is 70% of the digitized value from [We66]. For this case the fractional error estimate is 234.5% and the Signal-to-Background estimate is 2.99. The worst comparison point is Point 4 where the Data Base value is 0.8% of West's value. For this case the fractional error estimate is 17,080.0 and the Signal-to-Background ratio is 0.03. Thus Point 4 is far less reliable than Point 1, and the comparison data agrees with that. It is still not clear why the Data Base does not get the West value. The difference has got to be in the processing. To understand how the processing improved it is probably best to go through the history of the reported measurements made with this detector.

Data Analysis and Measurement History: The first use of the magnetic electron spectrometer was a 10 channel device on Discoverers 29 and 31[Ma63]. The spectrometer spanned the range from 94 keV to 1220 keV. No interference channels were part of the detector. The electron fluxes measured were the natural background in late summer 1961.

The second document written on the spectrometer was [We63]. In this document West tries to characterize the fluxes introduced by the Russian II and III tests. The spectrometer and satellite were designed to measure the STARFISH electrons, so the energy channels went to higher energies than the Discover instrument. Two interference (background) channels were implemented to try to sort out the effects of electron bremsstrahlung and high energy protons on the detectors. It appeared that only the upper three channels (1.63, 2.40, and 3.25 MeV) were affected significantly. The counting rate for the high energy interference channel vs. L shell before and after the Russian II burst is given in Figure No. 2 extracted from [We63]. Clearly it is important to have a detector that is monitoring the interference (background) during the actual measurements, as the dominant component appears to have changed from protons to electron bremsstrahlung after the burst.

Figure No. 2: Interference Background Measured Before and After Russian II

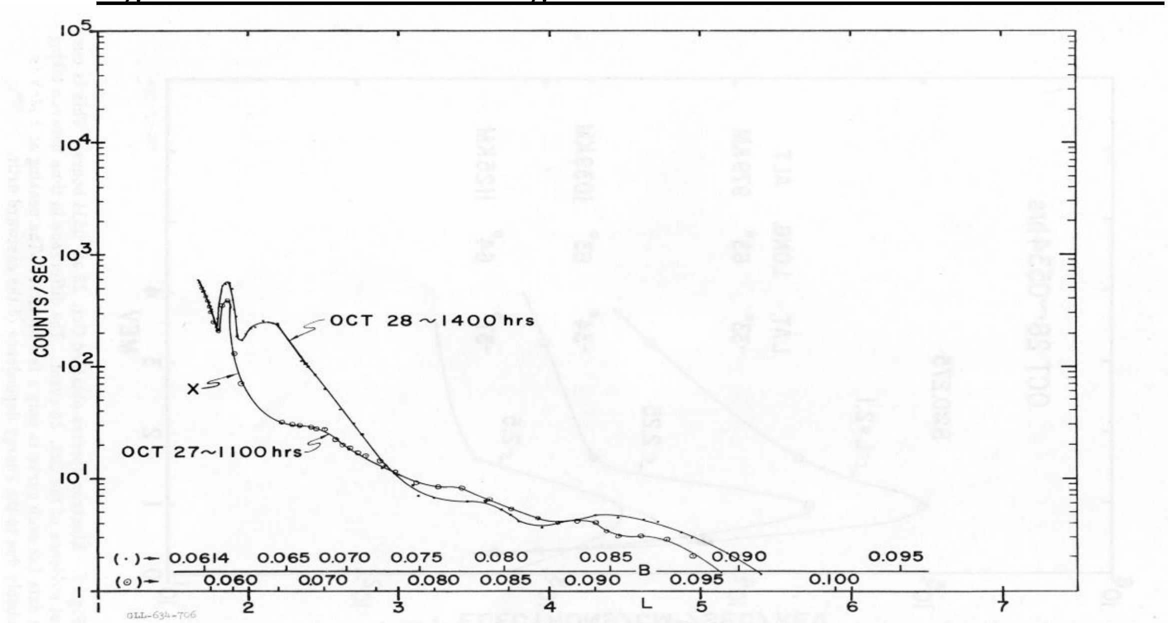


Fig. 4. The counting rate obtained in the 850-keV-threshold background channel before (Oct. 27 at ~1100 hours) and after (Oct. 28 at ~1400 hours) the Oct. 28 event.

West also makes the statement "Also most of the angular distributions are wide so that the reported fluxes are only slightly larger than isotropic." Implying that using the measured angular flux as an estimate of the omni-directional flux outside of the loss cone was not considered a bad approximation. He also reported the true background flux measured before the Russian II event in the figure reported here as Figure No. 3. He did not subtract this data in the curves reported in [We63]. His reported pitch angle distributions are significantly asymmetric about 90 degrees. He also used the first set of geometric factors reported above in Table No. 1. No mention was made as to exactly how the correction for interference channel data was made.

One year later West completed [We64] and used the second set of geometric factors reported in Table No. 1 above. These are the same ones used by Pfitzer when he compiled the first version of the STARAD data files. He estimated that the absolute errors in his fluxes were on the order of 20% and when position uncertainty was included they were on the order of 30%. He noted a timing error of 15 or more seconds in the reported time for each measurement. He also noted that the magnetometer produced plus or minus 5 degree errors in the actual pitch angles. The angular flux distributions about 90 degrees were usually not symmetric. He shifted the data to produce symmetry about 90 degrees, but does not make any statement about correcting for the timing errors or the magnetometer uncertainty.

Figure No. 3: Electron Flux Background Prior to the Russian II Event

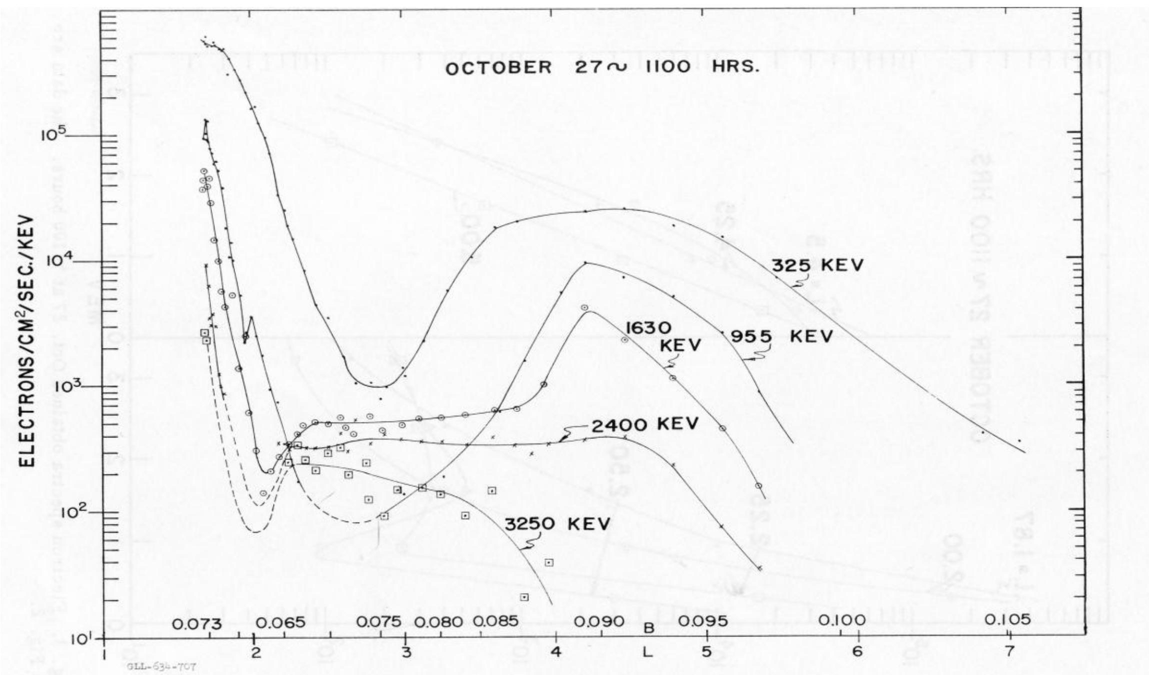


Fig. 2. A flux-vs-L plot of the data in each energy channel obtained Oct. 27 at ~1100 hours. These data serve as an approximate measure of the natural electron flux prior to the Oct. 28 event.

Unfortunately this report is aimed at reporting data outside of the region of interest for the Russian tests so there is no way of checking it against [We66]. Once again he makes no mention of how the correction for interference from high energy protons or electron bremsstrahlung was made based on the interference background detectors.

In RTEMF [We66] West reports the most extensive results for the Russian II burst. A direct comparison with his results at ~7.5 hours with the current data file is provided in Table No. 3 above. By this time he had realized that his calibration geometric factors were high by about 50% and so he corrected them to the third set reported in Table No. 1 above. Pfitzer apparently missed this and he used the second set reported above. The current data file has been corrected to use the set from [We66]. He does not mention timing errors or magnetometer

uncertainties. He also does not mention how the interference background channel data was used to correct the measured counts in the active channels.

Finally we come to the thesis by Kuck [Ku73]. In his thesis Kuck talks extensively about 1) calculating the actual magnetic field from satellite ephemeris data, 2) correcting time shifts in the data , and 3) recalibrating his detector. Note he did not use West's detector for his thesis work, but did develop a program for the calculation of the magnetic field and correction of time shifts that was applicable to all detectors on 1962 βK. He was assisted in this effort by re-digitization and analysis work performed at AF Cambridge Research Laboratories.[Ku73] This program was made available to Pfitzer for his work in 1982 [Pf82] and 1988 [Pf88]. Since he did not use the same detector as West, he mentions nothing about corrections to the upper three energy channels for the interference background measurements. However, since Kuck finished in 1973 and West's paper was in a compilation published in 1966, it is reasonable to assume that significant correction of the data went on during these seven years.

Conclusions: Not all of the answers have been tracked down for the differences between the data reported by West in RTEMF [We66] and the data files in the AFRL Trapped Electron Database. However, the integral file produced by Mr Burgio has been reconverted to a differential file and adjusted for the most correct set of geometric factors. This reconversion was validated by matching the recorded count rate data in the original file to within an RMS error of less than 0.8%.   In so doing it was possible to recover the interference background count rate data and that is now provided in all of the STARAD files. The differential file has been reconverted to an integral file to be compatible with other data files in the Data Base and matches the count rate data exactly. So there are now two files for the STARAD data on the Russian II and Russian III bursts. The new uncertainty estimates are consistent with Pfitzer's analysis and identify when data can be considered useful. The validity of the correction coefficients that Pfitzer used to correct for interference counts was never verified, but it is fairly certain which ones he used and how he used them. The methodology for correcting for magnetometer errors and time shifts was not uncovered explicitly, but identified as something that Pfitzer extracted from Kuck's and AFCRL's efforts. These last three corrections are most likely the source of the differences between the STARAD data files and the reported data in RTEMF[We66].

Therefore it seems reasonable to treat the new differential and integral STARAD data files as the most accurate information available. It is characterized by large uncertainties in many cases, and low signal-to-background ratios. But in many cases when the uncertainty estimates are reasonable and the signals are well above background, the data files should be useful.

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